

separate processor. Processor **12** can decide what haptic effects are to be played and the order in which the effects are played based on high level parameters. In general, the high level parameters that define a particular haptic effect include magnitude, frequency and duration. Low level parameters such as streaming motor commands could also be used to determine a particular haptic effect.

[0016] Processor **12** outputs the control signals to drive circuit **16** which includes electronic components and circuitry used to supply actuator **18** with the required electrical current and voltage to cause the desired haptic effects. Actuator **18** is a haptic device that generates a vibration on telephone **10**. Actuator **18** can include one or more force applying mechanisms which are capable of applying a vibrotactile force to a user of telephone **10** (e.g., via the housing of telephone **10**). Memory device **20** can be any type of storage device, such as random access memory ("RAM") or read-only memory ("ROM"). Memory **20** stores instructions executed by processor **12**. Memory **20** may also be located internal to processor **12**, or any combination of internal and external memory.

[0017] A proximity sensor **14** is coupled to processor **12**. Proximity sensor **14** detects when a finger (or stylus) is in close proximity to but not in contact with touchscreen **13**. Proximity sensor **14** may also detect location (e.g., x, y, z), direction, speed and acceleration, orientation (e.g., roll, pitch, yaw), etc. of the finger relative to touchscreen **13**. Proximity sensor **14** provides its information as an input to processor **12** when a finger is placed above touchscreen **13**. This input can be used by processor **12** when generating haptic feedback for telephone **10**.

[0018] Proximity sensor **14** may use any technology that allows the proximity of a finger or other object to touchscreen **13** to be sensed. For example, it may be based on sensing technologies including capacitive, electric field, inductive, hall effect, reed, eddy current, magneto resistive, optical shadow, optical visual light, optical IR, optical color recognition, ultrasonic, acoustic emission, radar, heat, sonar, conductive or resistive and the like.

[0019] In one embodiment, proximity sensor **14** includes one or more proximity sensors that each generate a sensing field above touchscreen **13** and that produce signals when an object disturbs or intercepts the sensing field(s). Each sensing field typically generates its own signals when disturbed. In one embodiment, a single sensing field is used to cover the entire touchscreen **13** surface. In another embodiment, a single sensing field only covers a portion of the touchscreen **13** surface. In another embodiment, multiple sensing fields are used to cover the entire touchscreen **13** surface. Any number of sensing fields may be used. In some cases, in order to perform tracking, the sensing fields may even be distributed as a pixelated array of nodes.

[0020] FIG. 2 is a flow diagram of the functionality performed by telephone **10** when generating haptic effects in response to the proximity of a user to touchscreen **13** in accordance with one embodiment. In one embodiment, the functionality of FIG. 2 is implemented by software stored in memory and executed by a processor. In other embodiments, the functionality can be performed by hardware, or any combination of hardware and software.

[0021] At **102**, proximity sensor **14** senses the presence of a finger, stylus, or other object above or in some other manner near touchscreen **13** or other input area of telephone **10**.

[0022] At **104**, proximity sensor **14** determines the position, speed and/or acceleration of the finger relative to the

surface of touchscreen **13**. This enables processor **12** to determine whether the user's finger will actually contact touchscreen **13**. For example, if the proximity signal is increasing at a certain rate, it is highly likely that the user will contact touchscreen **13** and press a button.

[0023] At **106**, based on the determination at **104**, processor **12** can calculate when the finger is expected to contact touchscreen **13**. In anticipation of this contact, processor **12** initiates the haptic effect before the actual contact, thus avoiding the lag time caused by actuator **18**. Processor **12** may use the acceleration of the finger and the starting time required by actuator **18** to determine how far in advance to initiate the haptic effect and energize actuator **18**. Therefore, the haptic effect will be implemented at approximately the exact time that the finger actually contacts touchscreen **13** and result in better synchrony of the haptic effect with the button press event. In another embodiment, processor **12** may initiate the haptic effect upon sensing the mere presence of the finger at **102**.

[0024] In typical use of cell phones or PDA's, the user generally holds the device in one hand and uses the other hand to interact with the user interface such as touchscreen **13**. For handheld haptic devices with proximity sensing this means that the user can sense the haptic feedback with the hand holding the device even though the finger has not yet touched the surface. Therefore, useful haptic effects can be created as a function of the proximity even when a finger never touches touchscreen **13**.

[0025] In one embodiment, if a user is hovering a finger over the touchscreen and moving over a grid of displayed buttons, a first haptic effect can be played when the user is moving from over one button to over the next button. The first haptic effect can be a short soft haptic effect in order to simulate the feel of moving over the edge of one button to the next. This first haptic effect will give the user an indication of the button locations without the user activating the buttons. A second haptic effect can be played when the user actually touches the screen and acts to select the button. The second haptic effect can be a strong haptic effect simulating a sharp button click.

[0026] FIG. 3 is a flow diagram of the functionality performed by telephone **10** when generating haptic effects in response to the proximity of a user to touchscreen **13** in accordance with one embodiment. In one embodiment, the functionality of FIG. 3 is implemented by software stored in memory and executed by a processor. In other embodiments, the functionality can be performed by hardware, or any combination of hardware and software.

[0027] At **202**, proximity sensor **14** senses the presence and position of a finger, stylus, or other object above or in some other manner near touchscreen **13**. The sensed position may include the x and y coordinates of the finger relative to touchscreen **13**.

[0028] At **204**, the functionality on the touchscreen is determined based on position of the finger. For example, if a multiple button graphical user interface on touchscreen **13** is displayed, the closest button that the finger is above and the functionality of that button is determined.

[0029] At **206**, processor **12** initiates a haptic effect based the functionality and location of finger. Depending on the functionality on the touchscreen, a different haptic effect may be generated by processor **12**. Because the finger does not actually touch touchscreen **13** in this embodiment, the haptic effect is felt by the other hand that is holding telephone **10**.